SEED PRODUCTION IN YUCCA GLAUCA

MAX M. ELLIS

In the course of other collecting in the autumn of 1912 some data were gathered concerning the amount of seed produced by *Yucca glauca*. It is well known that this plant depends upon the Yucca or Pronuba moth (*Pronuba yuccasella*)[1] for pollination, and that the larvae of the *Pronuba* in turn feed upon some of the developing seeds of the *Yucca*. As a result, *Yucca* produces an excess of seed. It is concerning this excess of seed and the number of seeds eaten that data are submitted. Seed pods of *Yucca* were collected and counts made at Boulder and Wray, Colorado.

1. Distribution of seed-producing plants

At Boulder counts were made on three mesas, one north and one south of the city, and one near the base of Flagstaff Mountain. On the south mesa 320 plants were counted and no seed pods found. Many of the plants (about half of them) had flower stalks still standing. Some of these stalks were discolored and worn, showing them to be more than a year old, but the majority of the flower stalks were of this year's growth. Occasionally a group of a few plants with old flower stalks, on which were old empty seed pods, was found.

On the north mesa 142 plants were counted and none with seed pods found. Of this number 80 had this year's flower stalks still standing and 12 had old flower stalks.

Only on the mesa near Flagstaff were seed pods found on this year's stalks. Here 210 plants were counted and 10 found with seed pods. These 10 plants were all included within a square of 200 yards.

At Wray observations were made on several mesas on the north side of the Republican River. No attempt was made to count all of the plants seen, but by comparison with the Boulder mesas at

[1] *Pronuba*, although generally used, is preoccupied. The name should stand *Tegeticula yuccasella*.

least 700 plants were examined. No seed pods on this year's stalks were found, and conditions were essentially the same as at Boulder. About one-half of the plants had flower stalks standing; some of which were old and some this year's growth. Several areas were noticed in which many of the plants bore old stalks with empty seed pods. Wherever these old empty seed pods were found, it was noticed that all the plants bearing them were in a rather restricted area (about 100 yards square), and that most of the plants within this area bore pods. On the south side of the Republican River a group of yuccas was found with seed pods on this year's stalks; 27 plants, all within a rectangle 100 by 200 yards, bore seed pods. Only the very small plants, of which there were 33 within this area, were without seed pods. On the other hand, although yuccas grew on both the east and the west of this group, no other seed-producing yuccas were found for a distance of 300 yards or more on either side. Table I shows that the seed production in this area was high.

TABLE I

Number of plants	Number of pods per stalk
6	1
3	2
8	3
6	4
3	5
1	7

The data collected show that the seed-producing plants are found in occasional small groups. These occasional areas are to be explained as the result of a very local, annual distribution of the *Pronuba* moth, the pollinating agent of this species. It is evident that a large number of yuccas flower every year, and it is hardly possible that all of these flowers are infertile were they properly pollinated. Allowing 10 blossoms to each stalk, it is seen that the number of blossoms produced annually in even a small area is very large. This points to an enormous waste by the species as a whole, as a result of the restricted pollination by a single species of insect, if the yucca moth is always so locally distributed. So far as could be determined, there were no barriers to a flying insect

between the areas of seed-producing yuccas and those without seed-producing plants, yet the local distribution of the seed-producing plants obtained in all cases.

2. Seed production

The seed pods as collected in the field were placed in small paper bags. In the subsequent counting of the seeds of each pod three classes were recognized. Seeds of the first class were termed perfect seeds; these were the uniform, well-filled, shiny black seeds which were uninjured, that is, they were apparently perfect seeds so far as could be determined by inspection. The second class included all the seeds injured by the larvae, and they are listed as seeds eaten. As the *Pronuba* larva grows it eats its way up through the center of the column of flat seeds, which are stacked vertically in the pod like a pile of coins. The seeds which had been eaten were usually ring-shaped, as only the central portion was destroyed. The diameter of the area destroyed increased as the top of the pod was approached, since the larva grew as it ascended the column of seeds. Often seeds taken from the top of the pod were almost completely eaten, while those from the bottom were perforated by holes 1 mm. or so in diameter. As a rule, the injured seeds remained in place in the pod and were usually cemented together by the excrement of the larva. There was some evidence that the seeds continued to fill out even after the larvae perforated them, as the seeds so injured were of about the same thickness as the uninjured seeds. The number of white infertile seeds was also apparently the same in the columns of injured seeds as in the columns of uninjured seeds. In the third group, termed imperfect seeds, were placed the infertile white seeds and the few malformed black seeds. In separating the seeds of this group and of group one there was a chance for error; it was often difficult to decide whether a seed was of one class or the other. Since most of the good seeds, however, were so well formed, this discrepancy is within the probable error. The data for the individual pods is given in table II, and the summarized results in tables III and IV. The pods from each stalk are listed separately.

The average number of seeds produced was about 300 per pod.

These were divided about equally between the perfect black seeds and the infertile white seeds. The malformed seeds were few and were generally at the bottom of the pod. The individual data

TABLE II

BOULDER PLANTS

Perfect seeds	Imperfect seeds	Seeds eaten	Seeds in pod	Number of larvae	Seeds eaten per larva	Per cent per larva
Plant 1						
133	128	60	321	2	30	9
157	159	0	316	1	0	0
165	153	0	318	1	0	0
Plant 2						
172	41	156	369	12	13	4
118	210	46	374	2	23	6
62	141	0	203	1	0	0
Plant 3						
15	102	139	256	3	46	18
5	132	86	223	3	29	13
Plant 4						
177	187	84	448	3	26	6
245	72	17	334	2	8	2
125	187	19	331	1	19	6
172	150	0	322	1	0	0
Plant 5						
72	104	58	234	3	19	8
151	166	1	218	1	1	0.5
Plant 6						
154	61	101	316	1	101	32
118	130	26	274	1	26	9
Plant 7						
232	52	0	284	1	0	0
Plant 8						
232	96	27	355	2	13	4
Plant 9						
125	105	95	325	5	19	6
Plant 10						
136	158	26	320	2	13	4
127	156	8	291	1	8	3

WRAY PLANTS

Plant 11						
72	91	36	189	1	26	14
63	12	195	270	2	87	32
27	18	169	214	3	56	26
31	27	180	238	9	20	9
76	50	147	273	2	25	9
50	50	64	168	2	25	15
Plant 12						
70	141	41	252	2	20	8
107	109	0	216	1	0	0
54	5	187	291	10	19	7

show a tendency at least for the pods on the same stalk to produce about the same number of seeds, although the number of pods per stalk is apparently not a factor. The highest number of seeds taken from a single pod was 448 from a pod of plant 4, which bore 4 pods. The lowest number, on the other hand (168), was from a pod of plant 11, with 6 pods.

TABLE III

	Seeds in pod	Perfect seeds	Imperfect seeds	Seeds eaten	Actual loss in per cent
Minimum	168	5	12	0	0
Maximum	448	245	210	187	64
Average	280	118	104	58	21

TABLE IV

	Number of larvae	Seeds eaten per larva	Per cent of seeds eaten per larva
Minimum	1	0	0
Maximum	12	101	32
Average	2.66	19	7

3. Relation of larvae to seed production

The most interesting point in connection with the seed production of *Yucca* is the presence of the larva of the *Pronuba* moth, whose existence depends upon the destruction of some of the seeds. Theoretically, a single larva to each pod would give the optimum condition for *Yucca*, as this would represent a single pollination by a parent *Pronuba*. If the number of larvae be greater than one per pod, the advantage is on the side of the *Pronuba* until the number of larvae is such that the entire mass of seed produced is destroyed. This last condition would of course exterminate the moth.

That one larva to each pod is the optimum number is shown by the fact that 9 of the 11 pods in which but a single larva was found produced the average number of perfect seeds or more.

The averages also show that *Yucca* is successful in seed production even against odds. The average number of larvae per pod found was 3, and of the 26 pods with 3 or fewer larvae 12 produced

the average number of perfect seeds or more. That the presence of a number of larvae in a single pod need not prohibit average seed production is shown by plants 2 and 9. A pod of the former produced 172 perfect seeds, although 12 larvae had been in the pod. The pod of plant 9 also produced good seed in excess of the average even though there were 5 larvae in it. The number of larvae present did not seem to have any effect on the total number of seeds (both infertile and perfect) produced.

The production of the average number of perfect seeds by pods with many larvae calls attention to the influence of parasites of *Pronuba*. Of the 30 pods examined, 7 were found without injured seeds. In several other cases, although some of the seeds had been eaten, the dried skin of the larva was found in the burrow in the seed column where it had died. It is well known that most species of insects are parasitized by other insects, particularly by minute Hymenoptera. These parasites are usually parasites of the egg or the larva of the host. The action of such parasites would account for the death of the eggs and young larvae of *Pronuba*. The result of the presence of these parasites would be advantageous to *Yucca*, for once the parent *Pronuba* has pollinated the blossom of *Yucca* its value to that *Yucca* plant ceases. The destruction of seeds by larvae is unnecessary, as proven by 7 cases, and, so far as the particular plant is concerned, disadvantageous. The advantage comes only to the species as a whole, in supplying food for the *Pronuba* larva. The elimination of some of the eggs and larvae of *Pronuba* by parasites could also be of value to *Yucca* as a group, if not carried too far. These egg and larva parasites aid in preserving the balance by reducing the number of larvae toward the optimum for the plant, thus saving the plant the seeds eaten by the extra larvae. If the 7 pods which lost no seeds as the result of injury by larvae be dropped, the average number of seeds eaten per larva is raised from 19 to 24, and the number lost per pod from 58 to 72. The destruction of the egg in these 7 cases makes this important change in the averages, and if the saving of seed to the plant by the destruction of the immature larvae could in some way be figured in, the change would be still greater. Of course these eggs and larvae may not have been destroyed by parasites, although that is rather

improbable, judging by the cases of other insects, but the factor of elimination of some of the eggs and larvae remains, and the advantage, from whatever cause, is to the plant.

In conclusion it is to be noted that *Yucca* is a successful plant in regions where the climatic conditions are requisite and *Pronuba* is found. The peculiar method of pollination by a single insect species, which is maintained at the expense of the plant, must then also be considered successful. The averages show that it is. An average pod produces 300 seeds, over 100 of which are perfect, at a loss of 58 seeds, that is 21 per cent of the total production.

UNIVERSITY OF COLORADO
BOULDER, COLORADO